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Nooteboom, Bart

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TOWARDS A COGNITIVE THEORY OF THE FIRM

Issues and a logic of change

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Bart Nooteboom²

e-mail b.nooteboom@bdk.rug.nl

SOM theme B: Inter-firm Coordination and Change:
Marketing and Networks

Abstract

The paper consists of three parts. The first part gives an inventory of issues that no cognitive theory of the firm can ignore. These are grouped into three themes: aspects of development, issues of coordination and philosophy of knowledge and language. The second part of the paper tries to develop a general logic of change, and to make this logic more determinate and rigorous with the aid of the notion of scripts. The third part gives an

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introduction to implications and applications for the theory of the firm and for management.

Introduction

There are three important developments in the view that economists take of the firm. One is that they are prepared to drop the notion of the 'representative firm', and to recognize that within an industry there are significant differences between firms: firms have distinctive competencies. The second is that economists are increasingly prepared to open up the black box of the firm, and to recognize issues of coordination between different entities and activities inside the firm. The third development is that transaction cost economics (TCE) has generated a growing recognition of forms of organization 'between market and hierarchy'.

Firms are striving under a regime of rapid change in technology and markets, with an increasing focus on innovation, learning and forms of cooperation between firms. In view of this, it is absurd that economics does not contain a well-developed theory of cognition and evaluation, by people and firms, in interactions between them.

There is an extensive business literature on learning in and by firms (see the special issue of *Organization Science*: 'Organizational Learning: Papers in honour of and by James G. March' 1991; and for a more extensive collection of papers: Cohen and Sproull 1996). But this literature tends to neglect issues in the philosophy of knowledge and language, and perhaps partly for that reason lacks an integrative conceptual framework (Huber 1996). This is understandable if we look at the breadth and depth of issues and literatures that would need to be taken into account in a more full and systematic cognitive theory of the firm. Yet, in my view this complexity has to be accepted. The present paper discusses some of the main issues that such a theory should address, provides the outlines of a theory that integrates these themes, and indicates some implications and applications. The text will be fairly compact; a full discussion requires a book. Here, the resource and competence based view of the firm (Penrose 1959; Foss 1993) is taken for granted: the firm has competencies, based on resources, embodied in various forms of capital (financial, human, social), which to a greater or lesser extent are idiosyncratic to the firm. It is such unique capabilities of firms that allow them a basis for profit.

The methodological orientation of the paper is evolutionary, in the sense that it looks at processes rather than only outcomes (such as equilibrium outcomes that mainstream economics focuses on), and in the sense that it will investigate process in terms of the central evolutionary concepts: sources of variety, selection and transmission. Does the composition of industries change by the adaptation of firms or by evolutionary pressures eliminating maladapted firms (Hannan & Freeman 1989)? The received view in the literature on organizational learning (Cohen and Sproull 1996), is that both mechanisms apply; they are complementary (Levinthal 1991). Note, however, that although in economic evolution we can recognize the central evolutionary concepts of variety, selection and transmission, there are many crucial differences between economic and biological evolution (de Bresson 1987). In particular, in economic evolution the behaviour of the phenotype (e.g. the firm) is not entirely 'hardwired', like instinctual behaviour in animals, but is amenable to a certain amount of 'reprogramming', by strategic re-orientation ('organizational learning'), and thereby has a much wider scope for adapting to the selection environment. Also, the selection environment, consisting of markets and institutions, is not as autonomous as in biological evolution. It can to a greater or lesser extent be transformed by firms' strategies: advertising and brand name, innovation, collusion, political influence. This latter point has been relatively neglected, but not, for example, by Prahalad and Hamel (1990), and the earlier Austrian school in economics, who emphasize entrepreneurial capabilities to create new conditions in technology, markets or institutions.

The disciplinary orientation of the paper is both economic and sociological, in the sense that it looks at the goal directedness and creative freedom of actors as well as the way in which creation is governed by institutions. Thus it tries to sail clear of both the economic vice of methodological individualism and the sociological vice of methodological collectivism.

Part 1 of the paper indicates a number of issues that a cognitive theory of the firm should take into account. To give some sense of order, we group the issues into three main themes. First, the different *aspects of development* that should be taken into account, concerning information, knowledge and learning. Second, since

we are dealing with multiple people, and multiple firms, there are issues of *coordination*, within and between firms, and the role thereby of markets and market failures. Third, we cannot evade *philosophical issues* of knowledge, language and meaning, individual and society, freedom and determinism. Further, to give some sense of direction, we indicate for each issue in those themes what role it is expected to play in the cognitive theory of the firm: as a problem to be solved or clarified, as a basic principle, as a concept to be used, as a method, etc. The basic, possibly heroic, hypothesis is that connecting and integrating these themes and issues there is an underlying 'deep structure' or 'logic of change' that we should try to discover.

In Part 2 the makings of such a logic will be sketched. The main conceptual instrument we use is that of a 'script', taken from the cognitive science literature. This notion serves two important purposes. The first is to solve the multi-level problem (or 'aggregation problem', as an economist might call it) in the step from individual learning to learning on the firm level, while at the same time establishing a link with the processes, in particular the primary process of production, that take place in the firm. The second is that it provides a basis for identifying, reconstructing and connecting different types of learning.

In Part 3 we give a preliminary discussion of some applications of the scheme.

Part 1: ISSUES

1.1 Aspects of development

One theme consists of the different aspects of development that are relevant. The issues here are: the tension between continuity versus change (or exploitation versus exploration), the identification of different forms of knowledge, types and degrees of learning and stages in the development of people, firms, technologies, products and markets.

Continuity and change

Change (or exploration) is required because conditions change. On the other hand, some stability or continuity is required to apply what one has learned (exploitation) (March 1990, Holland 1975). In evolutionary parlance: a certain amount of continuity in the *modus operandi* of a life form is required, as a basis for assimilating resources from the environment in order to maintain itself sufficiently to achieve procreation.

In biology, novelty arises from the random appearance of new forms of life (by mutations and pairings of parental genes). These will achieve a larger share in the total population to the extent that they have greater 'fitness' to the selection environment. The life forms cannot significantly change the selection environment to their advantage. They adapt to the environment rather than vice versa. In 'population ecology' (Hannan & Freeman 1984), a similar approach was taken to industries, where adaptation takes place only on the industry (population), and not on the firm level. In economics, entrepreneurship has been recognized as a source of variety; of the production of novel forms. There is a debate to what extent it is random and to what extent directed on the basis of intentionality and insight.

In more recent thought, and in evolutionary models (Boyd & Richerson 1985) allowance is made for a greater or lesser adaptability of firms: the ability to adjust their *modus operandi* to changes in the environment, and to transmit successful adaptations (Lamarckian inheritance). Thus, firms are seen as striving to achieve sufficient continuity, in order to utilize resources for the production of added value, as well as a sufficient ability to adapt to changing conditions. The mix of continuity and change that is most conducive to survival depends on the variability of the environment: more stability allows for more continuity; more variability

requires more adaptation³. But there is an unresolved tension between the two: how can change and continuity be reconciled?

In evolutionary theory more generally there is a tension between continuous and discontinuous or punctuated evolution ('saltation'), or evolution versus revolution, or cumulative versus structural change. Economics contains a tension between equilibrating (Walrasian) and disequilibrating (Schumpeterian) entrepreneurship. The latter remains a mystery. Schumpeter himself failed to endogenize invention: to him it was still like the drop of a stone in a tranquil pond, where one could subsequently study the ripples of diffusion. Is innovation inveterately exogenous, bound to remain a mystery, or can it be shown to somehow emerge from past practice? A paradoxical question is: if saltation is exogenous and cannot be explained, such a 'deus ex machina' is quite unsatisfactory, but if it can be reconstructed endogenously from what existed before, how can it still be discontinuous?

Adaptation by firms is associated with 'organizational learning'. In the literature a distinction is made between two levels: 'single loop' vs. 'double loop' (Argyris and Schön 1978), or 'first order' vs. 'second order' learning (Fiol & Lyles 1985, Hedberg, Nystrom and Starbuck 1976); 'exploitation' vs. 'exploration' (March 1990, Holland 1975). These dichotomies mean (approximately?) the same thing: in order to survive, a firm must have both sufficient continuity in its *modus operandi* to achieve efficient production (single loop, first order, exploitation). But a firm should try to adapt its *modus operandi* to changed conditions (double loop, second order, exploration). One of the central tasks of contemporary management is to achieve an adequate balance between the two. Perhaps the most important challenge in the theory of organizational learning is to elucidate the relation between the two levels of learning: how do they relate in the process of firms' operation and development? Is second order learning exogenous, or does it somehow emerge from first order learning, so that they can somehow be combined and no longer need to constitute a dilemma? How does this work?

³ This does not imply that firms will in fact adapt more quickly and frequently. As Heiner (1983) pointed out, if the demand for adaptation greatly exceeds the ability to adapt, behaviour may become more rather than less stable: one renounces the effort to adapt.

In view of the point made earlier, I would like to add 'transformation' to the notions of exploitation and exploration : the ability of firms not only to refine or optimize their *modus operandi*, and to adapt it to changed conditions, but also their strategic ability to adjust the selection environment to their *modus operandi*, to a greater or lesser extent.

Role in the theory: problem to be solved or clarified.

Forms of knowledge

It is useful to distinguish data, information and knowledge. To understand these concepts, we need a theory of knowledge (epistemology), and a theory of language and meaning (semiotics). We discuss those later, but have to anticipate a bit on them here. *Data* are literally 'givens': external sign material produced by *events*. Events include actions, which include gestures and utterances by people (sound making, writing), which include pronouncements (use of language), which include propositions (pronouncements that are carriers of truth values). The data from pronouncements are grammatical and syntactic structures of 'signifiers' that are used to express intended meaning ('signified').

People possess cognitive structures for *perception*, *interpretation* and *evaluation*. Perception produces data for interpretation. Interpretation entails the production of meaning, which transforms data into *information*, by fitting it into a stock of knowledge. *Understanding* connects and transforms information into beliefs or claims of causal or deductive insight. *Knowledge* is a meaningfully ordered stock of information (interpreted data), and understanding, plus ability to transform it into actions (skill), which yields *performance*. In saying this, I endorse the pragmatic approach to knowledge, which goes back to Wittgenstein (1976) ('meaning as use') and before that to the pragmatist philosophers (notably Peirce 1957). Apart from other philosophical merits of this view, a reason to include performance in the concept of knowledge is that one cannot judge knowledge apart from the judgement of performance. A second reason is that it fits well with the competence view of the firm. The third part of cognition, evaluation, entails a matching with goals and

values; a judgement of goal congruence. Perception, interpretation and evaluation plus skill to perform and commitment to goals yield action.

The economic and organizational literatures recognize that knowledge can be embodied in different ways: built into hardware (machinery, instruments), encoded in documents (including electronic information carriers such as tapes, discs and computers), absorbed by people (including teams of people). This does not imply that in the process of embodiment nothing is lost or added. On the contrary: something is always lost or left out, and things may be added, in the process of transfer of knowledge into a machine, a code or people. In particular, tacit elements are left out. The notion of 'tacit knowledge' will be discussed presently. For a further understanding of this we will later go deeper into language and semiotics.

From the work of Michael Polanyi (1962, 1966, 1969), the literature adopted the notion of tacit knowledge, which is embodied in people in such a way that it cannot easily be 'transcribed' into a code. This applies in particular to skills and to innovative practices, as we shall see later in our theory of learning. As an innovation 'settles down' into a 'dominant design', it can more easily be transcribed into documents, which then become data for other people. Before that, when knowledge is still tacit, it can be transferred only by imitation of the person or team that carries it, or by bodily transfer of the latter. The data are then uncoded, perceived bits of performance. But tacit knowledge may also be in the nature of a 'routine' that has become 'second nature', even though originally it had the form of an explicit, documented rule of conduct. In that process also things may have been left out or added. Thus, there is transition from tacit to documented knowledge, and vice versa (cf. Boisot 1995). The latter makes sense in view of 'bounded rationality' (in the sense of bounded cognitive capacity): in order to reserve capacity for the non-routine that demands attention, the routine subsides into non-awareness (Simon 1983). But this yields the problem of continuity versus adaptation that we indicated above: the tacit may be difficult to adapt.

The distinction between tacit and documented knowledge is close to the distinction between 'procedural' and 'declarative' knowledge (Cohen & Bacdayan 1994, Cohen 1991; the distinction seems identical to the distinction between 'non-

canonical' and 'canonical' knowledge employed by Brown & Duguid, 1991). Procedural knowledge constitutes an ability or skill to perform some activity. It tends to be implicit and tacit. Declarative knowledge constitutes explicit knowledge of facts, causal relations, etc. For knowledge to be documented it would first need to be declarative. One can have the one without the other. One can ride a bike without being able to explain how. Procedural knowledge tends to be retained longer than declarative knowledge. Having learned a language, later one can often recognize whether a sentence is well-formed, without recalling the grammatical rules for sentence formation (Cohen & Bacdayan, 1994). Then one can say that one knows the grammar in the procedural but not in the declarative sense.

Role in the theory: these concepts form elements for building the theory

Types and degrees of learning

Learning is growth of knowledge: gaining more interpreted data (information), or gaining understanding (claims of deductive or causal ordering), or gaining skill to perform. In modern mainstream economics there is recognition of the importance, cost and possible lack of information (search costs), and of different *types* of learning: learning by doing, imitation, search and formal learning. A similar distinction is made in the organizational literature. Learning by doing and imitation typically yield tacit, procedural knowledge, and search/formal learning is typically associated with the absorption of explicit, documented, declarative knowledge.

The term 'learning by doing' is ambiguous. One interpretation is: learning in the form of increased efficiency as a function of cumulative practice. Another interpretation is: novel ways of doing things that emerge from the practice of existing ways. The two are quite different: the first is a matter of narrowing; of eliminating steps that are redundant, or replacing ill-fitting elements by better ones, thus making a process more efficient. The second is a matter of widening one's perspective; of groping for novel combinations to arrive at a new practice. Both have their place in development, but they are not the same. We return to this in the later elaboration of a 'logic of change'. The discussion leads us to the notion of what we call (for want of a better term) *degrees* of learning.

Different *degrees* of learning are recognized. In non-mainstream economics there is a recognition of developments within a 'technological paradigm', and shifts of such paradigms (Dosi 1984). This idea was taken from the philosophy of science of Kuhn (1962) with his notions of 'normal science' within a scientific paradigm, and 'revolutionary' shifts of such paradigms. As we noted before, in the organizational literature, there is a distinction between 'single loop' versus 'double' loop learning (Argyris & Schön 1978), or 'first order' vs. 'second order' learning (Fiol & Lyles 1985, Hedberg, Nystrom and Starbuck 1976); 'exploitation' vs. 'exploration' (March 1990, Holland 1975). We hold these distinctions to be synonymous, and use the terminology of 'first and second order learning'. First order learning refers to the refinement and consolidation of existing cognitive structures, which is exhibited in a better performance of existing practice ('doing things better'), while 'second order' learning refers to the emergence of a novel practice ('doing better things'). It is also referred to as cumulative versus transformational learning, and then seems similar to the development within paradigms and the shift of paradigms. It seems to be related to our earlier distinction between learning in the form of increasing efficiency of an existing practice, and learning in the form of grasping for novel combinations in a newly emerging practice.

In both non-mainstream economics and organizational theory, there is a further division into three degrees of learning. In the organizational literature actions are seen to result from rules, which are based on insights, which are in turn based on principles. First order change involves a change of rules, called 'improvement', second order change involves a change of insights, called 'renewal', and third order change involves a change of principles, called 'development' (Swieringa & Wierdsma, 1990). In non-mainstream economics, a distinction is made between 'parametric change', which involves novel substitutions into given variables in a given structure, 'strategic change', which involves 'rearranging capabilities within existing boundaries', and 'structural change', which involves a change of boundaries (Langlois & Robertson, 1995).

Note that the distinction between first and second order learning is close to the opposition between continuity and adaptation. First order learning maintains

current ways of doing things, while second order learning shifts them. Thus it is as urgent to clarify the relation between first and second order learning as it is to clarify the relation between continuity and change (or between structure and process). The need for some balance between stability and adaptation supports Kuhn's argument for the rationality of a certain extent of theoretical conservatism in science. You do not and should not surrender a given 'paradigm' too soon. Not before the cumulative weight of anomalies with the existing paradigm has in some sense become excessive, and the indications towards a viable replacement are available. In organizational theory the relation between different degrees of learning and the issue of continuity versus renewal constitutes a major issue in the development of a 'learning organization'. Here, as more generally in the debate on continuity versus saltation, the different degrees of learning or evolution are presented as different, separate categories. Second order learning in organizational theory remains as mysterious as Schumpeterian entrepreneurship in economics. We need to show how they are related; how adaptation builds on continuity, and preserves sufficient continuity for adequate performance along the way. This is the main task of our later 'logic of change'.

Role in the theory: elements that are to be used but also clarified

Stages of development

The question arises whether perhaps different *degrees* of learning form *stages* in an overarching process of cognitive development, with in later stages higher degrees building on lower degrees of learning. Insight into such a process may help to clarify the issue of continuity and change.

The next question could be whether such a process bears similarities to life cycle theories of firms and products. In life cycle theories of the firm, an initial entrepreneurial stage of innovation, with an improvisational, informal and ad hoc way of doing things, is followed by consolidation into more determinate organizational structures and more managerial, formal, documented procedures and planning (Churchill & Lewis, 1983; Scott & Bruce, 1987). The problem then arises how after that stage a bureaucratized firm can still produce innovation.

In product life cycle theory, a 'fundamental' innovation, in the form of a new function or a radically new way of performing an existing function goes together with an initial phase of consolidation, with the development of a 'dominant design', followed by a stage in which attention shifts to greater efficiency by means of process innovation, and in which the market for the new product is expanded. This goes together with a wearing out of initial innovation monopoly, as a result of imitation by new entrants, and a resulting pressure on price, and pressure to reduce costs. One opportunity for this is to employ the expansion of the market to utilize economies of scale. This goes together with fast growth or take-over of successful entrepreneurs from the innovation stage. The basic technology has become standard, with a consolidation of tacit knowledge into documented and more easily diffusible knowledge.

Next, due to ongoing pressure on price, there is a tendency to differentiate products, in order to escape from pure price competition, to the extent that the market offers a potential for it. Whether the industry integrates or disintegrates in these stages depends on the possibility to separate different steps in the overall production process, by modularity on the basis of diffused know-how and standards for interfaces (Langlois & Robertson, 1995). At the end of the life cycle, the next innovation forms a substitute, and only small residual 'niche' markets remain, which tend to be exploited by small firms, who in that stage no longer face the disadvantage of diseconomy of small scale, and are less able to latch on to the novel innovation (Nooteboom, 1984a).

Is there, perhaps, some fundamental 'logic of change' underlying all these phenomena, as well as learning by people and firms? This may seem too heroic an hypothesis, but I will undertake it anyway.

Role in the theory: areas of application.

1.2 Coordination

The second theme consists of modes, levels and problems of coordination, within and between firms. This relates to issues concerning the 'boundaries of the firm'. Between firms it is related to 'governance between market and hierarchy'. This includes problems of 'spill-over', the role of distance, in a spatial but also in a cognitive and a cultural sense, in the coordination of activities, and the relations and differential advantages of small and large firms.

Institutions

Usually, institutions are defined as 'rules of the game' that constrain and/or direct actions of people. Thus they may serve to align cognition and action, in or between firms. They are also needed to constrain transaction costs within and between firms. This does not imply that existing institutions do in fact limit transaction costs. They may have arisen for the protection of vested interests, by raising entry barriers, or if designed to limit transaction costs they may not succeed or may even have adverse effects (Nooteboom 1996c).

Transaction costs are costs in the different stages of an exchange process: contact, contract and control. Contact costs are costs of search for an exchange partner, and of judging the quality of his offer or the nature of his needs. Contract costs are costs of drawing up a contract or other device of 'governance', prior to transaction, in order to enable control after the transaction. Control costs are costs of monitoring the performance of the partner, and influencing it to align it with one's own interests. Institutions may reduce transaction costs by a reduction of search costs (e.g. by some information technology and policy), or a reduction of contract costs (e.g. by a legal framework), or a reduction of behavioral uncertainty (e.g. by standards for conduct, or norms and ethics for 'normal conduct', as a basis for trust).

Institutions may subside into tacit habits or routines. Again, the advantage of this is that it allows for attention to be paid to non-routine, more urgent matters, and thereby economize on bounded cognitive capacity. Nelson & Winter (1982) go so far as to *define* institutions as routines. While I recognize the importance of

habituation in the regulation of conduct, I will not go along with this, since it is useful to allow for non-routine institutions. For example: deliberate, conscious efforts to install institutions such as the design of laws, mechanisms of social control, the building of trust. They may after a while become tacit and routine, but often are not so at the start.

Role in the theory: it is used to explore the role of organizational culture and other instruments in the management of learning.

Multiple levels

An obvious point is that learning appears to be an attribute of people, not firms, so that learning by the firm must be reconstructed from learning by people. This issue of the relation between person and firm has also been called the 'micro-micro'problem. The point that there can be no firm learning without personal learning seems inescapable, but some qualification is required, if the point is taken to go so far as to say that on the firm level there is nothing like a cognitive identity, and that firm cognition is a mere aggregate of personal cognition. Learning on the firm level may lie for the greater part in a re-arrangement of patterns of interaction between people rather than learning by those people. But admittedly, such re-arrangement is likely to work only if at the same time people adjust to the novel arrangement, and in that sense learn.

In the literature on artificial intelligence, one research tradition sees human cognition as a network phenomenon. Even in an individual, the notions of personal identity and memory, seen as constituting some 'core' in the form of an indivisible unit, are problematic. Memory and other parts of a person's psyche are distributed in the nervous system. If a firm is seen as a network of informational nodes in the form of people, combined with firm-specific institutions that constrain and guide their interaction, then metaphorically a firm may have an identity no less than a person, whose identity is also composed from a network of informational nodes (Nootboom, 1996a). We identify organizational culture with an institution in the form of a set of firm-specific symbols, (role)models and rituals that in some way constrain and direct the activities of the people involved, in particular their cognitive activities

(perception, interpretation, evaluation). As such, it contributes to a cognitive identity on the firm level.

Clearly, this does not eliminate the need to deal with issues concerning the relation between individual and collective learning in an organization. And there remains the fact that next to their organizational roles, people retain their identity 'qua persona' (Smith Ring & van de Ven, 1994). Personal interests and perceptions will diverge to some extent from shared ones. Indeed, the creative potential of an organization may lie in such diversity. Here again we come up against the issue of continuity versus adaptation. Organizational structure and culture may be directed to reduce that variety, for the sake of coherence and continuity, but alternatively culture may be directed at 'second order or third order' learning on the basis of individual variety. We will return to this crucial issue later.

We can carry the neural network metaphor further, beyond organizations into networks with organizations as nodes, and consider the possibility of a 'cognitive identity' of such a network, the tension between continuity and adaptation on that level, and the possible role of something like 'network culture'.

In a theory of the firm, we need to incorporate actions of people in the context of 'primary processes': the stream of entities in a process of transformation which adds value. The entities may be materials or goods (factory, transport, ...), people (transport, shop, restaurant, hospital, ...), information (insurance, banking, engineering, consultancy, ...), or, generally, combinations of them. In particular, information flows will accompany any primary process. In addition to these processes there are 'secondary processes' of support (finance, personnel, purchasing, R&D, general management), which in themselves entail processes of transformation. One way of visualizing this is Porter's (1985) 'value chain'. It is especially in such a constellation of processes that the link between the level of people and the level of the organization arises.

Role in the theory: a crucial issue to be resolved.

Boundaries of the firm

Our cognitive approach will add considerations on the boundary of the firm to already existing insights, and for this it is useful to give a summary of those insights.

As indicated by Langlois & Robertson (1990, 1995), in the economic literature there are two approaches towards the boundaries of the firm: from the perspective of ownership and from the perspective of coordination. These are to a large extent inspired by notions from recent streams in economic thought: 'property rights', 'nexus of contracts', 'transaction costs', which entail issues of 'incentive alignment', 'bounded rationality, impacted information', and ensuing problems of 'measurement and monitoring'; 'specific assets' and ensuing problems of 'hold-up', etc. Ownership is understood as the possession of 'residual rights' (revenues after deduction of claims from 'specific rights' allotted to suppliers of capital or services). Coordination is associated with 'hierarchy', i.e. direct control of performance, with an authority to demand the provision of information and compliance to agreements which would not stand up in court vis-a-vis an outside firm.

A standard argument in favour of the market, in the form of non-integrated, specialized production in firms under separate ownership and coordination, is that it stimulates effort since one is responsible for one's own survival as a firm, and one has to compete with alternative suppliers. In other words: the market provides stronger incentives for effort.

Some arguments for integrating different activities under unified ownership or coordination are related to the notion of 'complementary assets' or 'economy of scope': when combined in a unified process, certain products can be produced more efficiently, or certain production factors can be used more productively. Such economy of scope is 'inseparable' if it does not obtain if the assets are separated in some sense. The question is: in what sense? Separation in time and/or place, in coordination or in ownership?

In a static setting, integration of activities under unified or shared *ownership* may be required in the case that assets or products are complementary, and the monitoring of performance is problematic. Then in order to ensure incentives in the utilization of such complementary assets, that party should have ownership in terms

of residual rights, whose performance is most difficult to monitor by outsiders. With specific rather than residual rights, that party is most tempted to shirk. A further reason for integrated ownership may lie in strategic considerations: take-over a potential competitor to foreclose competition, or as an alternative for a cartel when that is precluded by law; backward integration to ensure privileged access to a source of inputs; forward integration into distribution channels to prevent free riding in the maintenance of a brand name (Daems 1983), or to establish impacted information vis a vis consumers on the basis of exclusive distribution (Francis 1983). As pointed out by Teece (1986), in a more dynamic setting of innovation, it may be necessary to keep the exploitation of an innovation within the firm where it was generated, if there is no other way to appropriate the rents from the innovation. In the case, for example, that there is insufficient patent protection, or insufficient control of compliance to licensing agreements.

Unified *coordination* of complementary assets, in a 'hierarchy', may be required in a static setting under several conditions. One is the presence of inseparable economy of scope, in the sense that activities can be performed more efficiently under unified coordination than when separated. This may occur in production, but especially in R&D (interaction with engineering, marketing and purchasing). Note that this does not imply that a complementary asset should also be *owned* by the coordinating agency. Integration in ownership is required if it is impossible to hire in the complementary factor from an outside firm on a spot basis. This may be so because it is part of the idiosyncratic competence of the focal producer, and therefore simply is not available outside. Or less extremely: for reasons of learning some continuity in the provision of the factor is needed to realize the economy of scope, or it requires specific investments on the part of the supplier, to ensure consistent coupling with the producer's process. As discussed in the previous section, integration in ownership may be needed if even under integrated coordination monitoring is problematic. In particular, integration may be needed to prevent hold-up (misuse of dependence of the partner) in case specificity of complementary assets yields switching costs that punish exit from the relation, which then is no longer viable as a deterrent of hold-up.

In a dynamic setting, Langlois & Robertson (1995) pointed out that if different steps of a value adding process are systemically linked, then change in each should be kept in unison with change in contiguous steps, and this may require integration under unified coordination, due to 'dynamic transaction costs' (defined as problems and costs of transferring new knowledge to others; or coordinating across different sets of knowledge). When change is minor, and kept within existing standards for interfaces between the steps, disintegrated change is feasible. But when change is more fundamental, and interfaces have to change along with steps, unified coordination is required. However, Langlois & Robertson (1995: 135) recognize that there also is 'a kind of radicalness ... that large organizations do not handle well. For this type of uncertainty, a decentralized network does much better'.

In a dynamic setting there is a dilemma of 'focus versus scope' (Nooteboom 1992a), which is connected to the dilemma of exploitation and exploration. On the one hand, to achieve anything, and to have any hope at winning races in technologies and markets, firms must focus on activities where they have or can achieve competitive advantage ('core competencies'). On the other hand, firms must maintain sufficient scope of monitoring developments that may yield opportunities or threats. I proposed (Nooteboom 1992a) that this dilemma can be solved by employing outside firms as sources of information and learning, in the utilization of 'external economy of cognitive scope': firms can employ the complementarity of knowledge between firms, arising from diversity in the path-dependent development of knowledge. Such cooperation can take a variety of forms: equity integration (sales of assets, merger/acquisition, equity joint venture), but increasingly also, or even preferably, non-equity forms, such as licensing, franchising, or partly non-contractual forms of cooperation in R&D, product development, distribution, export/import (Contractor & Lorange 1988). I briefly summarize the reasons for this (Nooteboom 1992a).

Due to rapid technological development and 'globalization', firms increasingly find themselves engaged in races: in keeping up with technology and in getting novel products to market. It is facilitated by the development of information and communication technology, which reduces transaction costs and shifts markets more

in the direction of the economist's ideal and the business man's nightmare of perfect competition. Information about supply and demand is more rapidly and more adequately acquired (search costs decline). Management can more easily coordinate activities across large distances (coordination costs decline). Thus there is more pressure and more opportunity to locate activities where they are most efficient. As a result of globalization, there are several pressures towards radical product differentiation. Technological development, in particular information technology, yields flexible methods of production, and acts as an enabling cause⁴. Individualization of consumer behaviour provides a market opportunity for differentiated products. Increased competition provides an incentive, to reduce pressures of price competition by means of product differentiation. But radical product differentiation greatly increases the complexity of both input and output markets, and to be 'sustainable' (Zuscovitch 1994), it requires that firms concentrate on core competencies, and outsource as many activities as possible. In particular, rather than claiming to have full competence in all dimensions of their products and production processes, firms should make use of the specific competencies of suppliers not only in production, but also in the process of research and development. Rather than making blueprints of required inputs that are 'thrown over the wall' to suppliers, there should be 'early supplier involvement' in the design process (Helper 1991, Lamming 1993). As a result, next to the central competence of achieving an adequate balance between exploitation and exploration, and indeed as part of that competence, a crucial competence of management now is its ability to design a good architecture of relations inside and outside of the firm (Kay 1993).

The mutual entanglement of firms further increases the specificity of investments in the transaction relation. As indicated in transaction cost economics (TCE), this yields dependencies and risks of 'hold-up', which raises complicated issues of 'governance' of relations between formally independent but materially dependent firms, in forms of organization 'between market and hierarchy' (Williamson 1985).

⁴ In particular information technology: programmable machines, computer aided design, simulating rather than building prototypes, etc.

However, in the present paper I will not deal with the complicated issues of governance of inter-firm relations in any detail (for that, see Nooteboom 1995).

In the transfer of knowledge to partners, one should take into account that there is a danger of 'spill-over': of crucial knowledge, which forms part of one's competitive advantage, spilling over through the partner to a competitor. Therefore, the conditions for spill-over and ways of controlling it should also be part of the cognitive theory of firms.

Role in the theory: Area of application.

1.3 Philosophical issues

This theme includes epistemology (philosophy of knowledge) and related philosophical issues of language and meaning, and issues concerning the relation between individual and society, and between freedom and determinism.

Epistemology

Any theory of information, knowledge and learning is based, explicitly or implicitly, on some epistemology. A hesitation to enter the thickets of this branch of philosophy is understandable. One can ignore the issue, but this only results in the tacit use of some epistemology that is taken for granted and is not subject to critical reflection and debate. A crucial issue, in particular, is the old philosophical question whether we can assume intersubjective knowledge which constitutes objective truth. Can we know reality as it is in itself, and do we in fact have such knowledge for at least part of reality (in the form of indubitable facts)? The philosopher Kant already gave a negative answer. To say yes to this is to adopt the stance of metaphysical realism.

This, in fact, is the stance of mainstream economics⁵. Modern mainstream economics accepts that there are costs involved in acquiring information (search

⁵ Which is not to say that economics is realistic in its assumptions. It is to say that economics traditionally assumes implicitly that people have cognitive access to reality as it independently from their cognition, yielding intersubjectively identical knowledge. This is not realistic. Cf. Hodgson (1988) & Nooteboom (1992a).

costs), which form part of transaction costs. There is recognition of 'bounded rationality', which then mostly means 'lack of information'. It is on the basis of this implicit epistemology that economics, up to and including rational expectations economics, holds on to its core concept of rationality: information, *in so far as available*, is used 'correctly', and no systematic 'errors' are made in the making of choices or in the making of probabilistic assessment and predictions. Lack of 'errors' in choice here means compliance with the axioms of choice, such as transitivity of preference. Lack of such transitivity would entail an 'error', but this is assumed not to occur.

In fact, it has been argued before that if we accept that products are to be seen as a bundles of characteristics along different dimensions of utility, as a point in a Lancasterian product characteristics space, intransitivity may quite plausibly occur (see e.g. Nooteboom, 1984b). But more fundamental, and much less debated, is the assumption that there is a well-defined 'correctness' in the use of information.

In my view we cannot get around the Kantian problem that we perceive, interpret and evaluate the world on the basis of categories of cognition (embracing perception, interpretation and evaluation) on the basis of categories, which prevent us from seeing and understanding the world 'as it is in itself'. I subscribe to the line of thought in 'constructivist' epistemology, or the 'interpretive approach' (Berger & Luckmann 1966), related to the perspective of 'symbolic interactionism', according to which categories of cognition evolve (somehow) from interaction with the physical and social environment. This perspective goes back to G.H Mead (1934). This entails path-dependence of cognition, and a lack of shared perceptions and understanding between subjects to the extent that their cognition evolved under different conditions and in isolation from each other.

In this perspective, data have significance, i.e. constitute information only relative to cognitive categories, and as a result data supply different information to different people. As a result, the notion of some objectively given 'correct use' of information is utterly problematic. The very notion of information as something apart from people to which it constitutes information, is problematic.

The constructivist perspective is relativistic in the sense of making meaning and understanding relative to categories, which differ to a smaller or greater extent between people. It is not relativistic in the sense of seeing no perspective for critical debate; for an intersubjective basis for correcting idiosyncratic error. While facts are always to some extent 'theory laden', they are intersubjectively more stable and reliable than theoretical speculation. This is perhaps best explained from an evolutionary perspective: facts have survived longer, in more different contexts, in more selection environments of intersubjective debate, than novel theoretical speculation, and are in that sense more reliable. But they are not reliable in any absolute sense: they may be mistaken, and the theoretical speculation that they claim to falsify may later turn out to be consistent with experience in a different interpretation. Only evolution in the longer run will show (and even then not in absolute terms).

Role in the theory: basic principles of knowledge.

Language and meaning

Since in human systems learning and communication are hard to separate, a learning theory of the firm can hardly evade issues of linguistics and semiotics. We need to examine those issues to proceed with the issue of intersubjective correction of idiosyncratic error indicated in the previous section.

Communication requires language, which contains a tension between the intersubjective order that it provides ('langue', in Saussure's terminology), and without which there would be no mutual understanding, and idiosyncratic language use (Saussure: 'parole'), without which meanings would not change and innovation would be impossible (Saussure 1915). Langue provides the basis for communication, and parole its source and agent of change.

In communication there is a sender, who engages in 'speech acts', where he exercises parole in first forming an idea of what is to be communicated: the 'signified'. This is encoded by means of 'signifiers' taken from langue (lexicon and grammar). For the receiver this is at first a mere datum. If it can be absorbed, i.e. when it 'fits' into 'cognitive structures for the production of meaning', it becomes

information for the receiver, where the receiver infers ('produces') a signified, to be taken up further into cognitive processes. What do we mean by 'cognitive structures for the production of meaning'?

Elsewhere in the theory of language, a distinction has been made between on the one hand 'reference' (with its synonyms 'denotation, extension'; Frege: 'Bedeutung'), and on the other hand 'sense' ('intension'; Frege: 'Sinn')⁶. Reference is that which a term refers to, which may be an individual or a set of individuals, and a truth value in case of a proposition. According to Frege, sense refers to how reference is given or identified ('Die Art des Gegebenseins'). Reference is subject to intersubjectivity and argument, in the 'context of justification'; in langue. Sense, on the other hand, is idiosyncratic, and rooted in personal experience, and produces parole. It resides 'in the context of discovery', and is a source of both error and innovation. Or, to put it differently: sense constitutes what we indicated before as 'production of meaning' for an actor. It is through sense that the recipient in communication infers the signified from signifiers. Along these lines, which are certainly subject to further elaboration, the connection between parole-langue and sense-reference emerges. In Evolutionary parlance: in langue, intersubjective matching of reference constitutes the basis for selection⁷. Langue also provides the vehicle for transmission, as a fund of signifiers, while sense provides the basis for absorption, or the inference of signified from signifiers. Thus langue and parole jointly provide and determine transmission. But parole also is the source of variety. Thus we arrive at an evolutionary theory of language.

There is a problem of communication across different sets of knowledge, which yields 'dynamic transaction costs'. In a radical form, it may yield what Kuhn called 'incommensurability' between different paradigms, if they entertain different

⁶ Cf. Geach & Black (1977); Thiel (1965).

⁷ This is probably connected with Habermas' notion of "communicative action" (Habermas, 1982).

ontologies⁸. Radical impossibility of communication is unlikely to the extent that there is any commonality in the history of the development of cognitive categories in at least partly overlapping worlds and cultures. But there may be serious difficulties in bridging the gap between those who have grasped some novelty, but cannot explain it (even to themselves) in terms of existing categories. Here, metaphors are needed as a bridge between the existing and the new. As a result, especially in early stages of innovation, debate will tend to be metaphorical rather than literal. Metaphors are needed for heterodox parole to make a claim to at least temporary tolerance in langue. Information, i.e. literally the result of 'making sense', i.e. signifieds inferred from signifiers, is never identical between subjects. Even identical twins will have non-identical sense, due to even minor differences in experience.

I propose that this conceptualization of language is useful, if not essential, for connecting the following issues in our cognitive theory of the firm: continuity and adaptation, culture and the micro-micro problem. As follows: In organizations, the issue of continuity and adaptation in firm conduct and cognition is strongly connected to the scope for parole (change) versus the constraints of langue (continuity), regulated by culture, in generating aggregate firm behaviour from personal conduct.

The issue concerning the relation between an individual and its interlocutors extends from the relations between people in a firm to the relations between firms, and the issue of the boundaries of the firm. In the multi-level theory that we need to develop, we must not only lift cognition from the level of the individual to that of the firm, but also lift language to communicative interaction between firms. Our theory of learning should extend across boundaries of the firm to market processes.

Here, there appears to be a connection with the old Austrian notion of the market as a 'discovery process'. However, the cognitive perspective of the Austrians was both shallow and narrow, in that it lacked both psychological depth and sociolo-

⁸ Perhaps we could say that they are incommensurable in the sense of yielding different quantification in the logical sense (classes of existents in presumed worlds). This incommensurability seems clearly related to Quine's (1960) notion of the "inscrutability of reference".

gical breadth , as was argued by Woo (1994). The Austrians (Von Mises, Hayek) are said to be subjectivists, but in fact the Austrian subject remains a black box. She was put on a pedestal, to be revered rather than studied. She is supposed to be rational, self conscious and creative. She does lack information, but 'picks it up' from the market, which is seen as a discovery process. Prices signal scarcity, and guide the entrepreneur in her search for profitable enterprise. Even in Schumpeterian economics, innovation is exogenous, as an unexplained emergence of 'novel combinations'. The formation of perception, knowledge, insight and evaluation, and the role of interaction between people, are absent from the theory. So, while in the later development of neo-classical economics the subject was ushered out, in the transition from considerations of utility to a pure logic of choice, in Austrian economics she is present but empty: there is no theory of how subjects develop knowledge and form preferences. Furthermore, in Austrian economics the subject is sacrosanct, autonomous and in no way formed by her environment. In this, Austrian economics is as much based on methodological individualism as neo-classical economics is: no allowance is made for effects of socialization, intersubjective interaction or institutions on the formation of knowledge and preferences.

Role in the theory: basic principles of communication.

Freedom and determinism

Finally, we face the perennial issue of choice versus determination, which is closely associated with the division between economics, with its methodological individualism, which implies complete individual freedom, and sociology, with its methodological collectivism, which implies a degree of determinism. The question is: if we find a social and psychological mechanism which forms knowledge and preference, and a subsequent mechanism of choice, to what extent is that choice still free? If we can reconstruct processes of high degree learning, and innovation, to what extent is the outcome of such processes still novel?

The answer is in fact a simple one: One can very well hope to specify a logic of change, in the form of meta level principles that form the basis of a process of development, without claiming to be able to predict the outcome in any specific

case. On the basis of well specified principles there may be chaotic outcomes, as chaos theory has demonstrated.

Role in the theory: Problem to be clarified; area of application.

Part 2: DEVELOPMENT

Now I try to set up a logic of change, which elaborates, clarifies and integrates the themes set out in Part 1. The central purpose is to describe the process by which on different levels (people, firms, networks of firms) higher degrees of learning (second order, third order, strategic, structural, transformational, developmental) emerge from lower degrees (first order, parametric, improvement), and thereby clarify the relation between continuity and change.

2.1 A logic of change

Novelty does not spring forward ready-made and out of the blue. This happens only in the ancient Greek myth of the goddess of war and wisdom Athena springing fully armed from the brow of Zeus. New things (concepts, products, technologies) at the outset tend to be indeterminate. They emerge as a groping at hints of something new; as intuitions that need to be elaborated and made more firm. When a person acquires a new practice, this tends to be ill-defined and messy, with encumbrances from previous practice, and lapses back into that more familiar practice. This is most pronounced in the case of learning from practice: a novel way of doing things seems to suggest itself, but it is not clear why or how precisely it should work. An inventor once exclaimed: 'I have got it, but I do not know how to get it'. But also in formal learning the phenomenon of initial confusion and stumbling arises, and practice is needed for the novel activity to be mastered smoothly. Repeated trials and application are required to find out what properly belongs to the novel practice and what not. In innovation, time and experimentation are required to arrive at a 'dominant

design'. The emergence of one outcome among possible alternatives may be influenced by chance and coincidence, such as the availability of adequate materials, skills, instruments, etc. This may lock development into a path that under later conditions is not optimal. Let us call this development from an indeterminate to a determinate novelty the *consolidation* stage, as the first stage of development.

This first stage is characterized by increasing efficiency from a process of narrowing; by elimination of what step by step is found out to be redundant. It is associated, I propose, with the 'experience curve' in economics, which is also, and in the present context confusingly, called the 'learning curve' (Yelle 1979). I propose that this corresponds to the notion of the emergence of a 'dominant design', and of 'standard operating procedures' (SOP). These then serve as 'prototypes' for further applications. Perhaps this is also associated with the concepts of first order, or parametric or improvement learning: learning to conduct an existing practice more efficiently by optimal substitution into given variables in a given structure.

After the novelty has settled down, and 'come into its own', one could not possibly step directly to the next novelty. Such a leap is difficult to imagine. First of all, there is Kuhn's argument, indicated before, that it would be uneconomic to switch to a novelty as soon as the first failure of the existing practice appears. One does not throw away one's present tools until a better replacement is at hand. Thus instant falsification of theory, as a perhaps too simplistic reading of Popper would seem to require, is uneconomic. And one would not survive with such change without continuity. Evolution would eradicate such jumps into the dark without taking time to exploit what has just been achieved. Secondly, one would have no clue where to look for the next novelty. I propose that one needs more or less extensive practice, to accumulate the incentive from failures, and to develop hints and elements for the configuration of the next novelty. Let us speculate how such a process is likely to proceed, if due to evolutionary pressures it is to proceed effectively and efficiently.

The most straightforward way to explore the limits of effectiveness or validity of an existing practice, and at the same time survive by ongoing production on the basis of resources and methods at hand, is to generalize the application of the

practice to novel areas. This what we see in individual development as well as development of firms and markets: attempts are made to carry a successful practice into neighbouring areas of application. This second stage we call the stage of *generalization*.

Next, it is to be expected that as one moves to novel contexts, the practice needs to be differentiated to fit into them. Here, the process of narrowing by eliminating redundancies, in the first stage of consolidation of novelty, is reversed into a process of widening into different versions and extensions of the novelty. Perhaps this is to be associated with second order, or 'strategic' or 'renewal' learning, in which variables are re-arranged within a given structure. This third stage we call the stage of *differentiation*. In this stage chance plays a significant but limited role: the extent and direction of differentiation depends on the direction and scope of generalization.

As the area of application is expanded, differentiation messes up the clarity and efficiency of the existing concept or practice, and failures to perform are accumulated. Furthermore, the practice impinges on the areas of application of other practices, that before seemed quite unrelated to present practice. Failures of one practice are compared with successes of the practices it has come in contact with, and speculations and trials arise concerning possible re-combinations of elements from different structures. Perhaps this can be associated with third order, 'developmental' or 'structural' learning, in which experiments are made with unorthodox novel combinations of elements from different practices. This fourth stage we call the stage of *'reciprocation'*. In this stage the importance of chance increases: we are in the field of serendipity. Connections between different bits of experience occur more or less at random. However, they are not completely random: the scope for recombination of elements is determined by the variety of differentiation in the previous stage. The (more or less) random combinations are idiosyncratic: different people will consider different connections; most of them without much useful effect. Most people will have tasted the sweetness of beet root. But it took an entrepreneurial leap of imagination to get the idea of developing sugar beet as a substitute for cane. In this way, reciprocation provides the source of variety that is

required for evolution. When a random combination with potential occurs, it is not easy to identify, since it literally does not make sense; it cannot be recognized. A handful of people stumbled upon X-rays, but only one saw what it might mean, and its implications might be.

This process of groping around novel combinations may hit upon successful performance. Then, we are back at stage one, but at a 'higher' level of development: a consolidation of something new that is as yet indeterminate, fuzzy, ad hoc, and unexplainable, since it extends beyond established meanings and corresponding categories, but perhaps intuitable by means of metaphor.

Such a cyclical process of development seems consistent with the exigencies of survival: it indicates a path along which one can proceed from what exists towards novelty, in a way that satisfies the need for present production along the way, while building up the incentives, hints and elements of novelty along the way, and thus reconciles the exigencies of both continuity and change. I note that the process corresponds point by point with Jean Piaget's notion of stages of 'assimilation and accommodation' (Piaget 1970, 1974)⁹. In its emphasis on the interaction with practice as a source of learning, it has affinity to the approach of Kolb (1984). In its recognition of the creative role of randomness, serendipity and metaphor (in the stage of reciprocation) it has affinity to Nonaka (1991, 1994).

⁹ After an accommodative shift of categories of understanding, there are subsequent stages of assimilation: repetition and recognition (to make the novel category more determinate), generalization, differentiation and "reciprocation" with other categories, which provides hints for a reconfiguration into a novel category. Piaget's theory was inspired by his experiments in the development of intelligence in children. We will not enter upon the debate to what extent the theory is in line with the empirical evidence, and the methodological adequacy of the experiments (see Flavell, 1967). In fact, my proposal for a "logic of change" was inspired by the work of Piaget, as I described earlier (Nooteboom, 1992a, 1989). But here I want to present it independently from the work of Piaget, as a reasonable hypothesis that ties in with the issues discussed in Part 1.

2.2 Scripts

Before attempting empirical tests, we should try to make the 'logic' more clear, determinate and rigorous, by some appropriate means of formalization. I will not be able to develop the argument fully in this paper, but I take a step in that direction by trying to apply the notion of a script. I will not be able to explore its applications extensively.

Research in cognitive psychology and linguistics indicates that the development of mental categories (things by which we identify and classify objects) is not simply a process of checking features of an object against a list of features required for class membership (Neisser 1987). Categories are not simple sets of entities with a list of attributes, but 'graded structures' (Rosch 1978). In categorization, attempts are made to fit things into a *connected and ordered* conceptual *structure* which can be seen as a network. A theory is a highly developed and explicit form of network.

A script is a specific case of such a conceptual network (Abelson 1976, Shank and Abelson 1977). As illustrated in figure 1, a script consists of a sequence of nodes. With these nodes correspond sets of events or actions, which allow for different 'permissible alternatives' or 'functional equivalents', or 'functional complements', called 'terms', that may be substituted into the nodes (like values into variables in a mathematical formula).

figure 1: script

script	script1	script2	script3
3 /	3	3	3
3/	3 _t	3 _t	3 _t
node *--- substitutable	---*	---*	*- reference
3\ terms t	3	3	3 line for t
3 \	*	*	3
node *	3	3	3
3	3	3	3
*	3	3	*
3	3	3	3
3	3	3	3

The sequence may be temporal, logical or causal. Scripts may not be like trees: branches may fold back to the trunk, as illustrated in figure 2.

Scripts are schemas for both understanding and behaviour. This pairing of understanding and behaviour connects with the view, proposed among others by Wittgenstein (1967), that to understand something is to be able to correctly perform a practice. This aligns with the American tradition of pragmatism. I propose that understanding an event or behaviour is the ability to fit it into a script. Information is data fitted into scripts. Having knowledge is having scripts, which form a behavioral repertoire. A script is cued by a 'script pointer', which activates the script as guide for behaviour or a basis for understanding by fitting events into the script. The latter process is called 'assimilation'.

figure 2: folding back

node A

node B node C

node D

Consider this example taken from Shank & Abelson (1977). In a dinner script, the nodes may be courses and a set of terms could be, for example, the set of alternatives we could use for butter, and complements of butter such as a knife (or the latter's functional equivalents). Or the set of things we might put on our bread (cheeses, meats, jams, etc.) in a subsequent node.

Scripts are found to play an important role in the construction of categories and meaning. Young children are found to classify objects not according to adult abstractions such as form or material, but according to their place in scripts. Not metal spoons, boxes, hammers, pans; not round objects of wood, metal, plastic, clay; but wooden spoons, metal forks, plastic plates and linen napkins, in an eating script.

As illustrated in figure 1, a term may be a substitute into nodes of different scripts, and these are connected with what I call a 'transscript reference line'. This choice of terms is related to the application of scripts to language. I propose that in many cases texts also can be modelled as scripts, and that this can be used to clarify the notions of meaning and language that we indicated before: langue/parole; intension/extension¹⁰. Grammar and syntax provide the rules for forming the axis of the script, with its sequence of nodes. A lexicon provides rules for substitution into

¹⁰ It was used for this purpose also by de Saussure (1915).

the nodes. An individual act (including 'speech acts' and acts of production in a firm, or transaction between firms), constitutes a substitution into a node in a script. Intersubjectively shared scripts of communication constitute language, as those in production constitute established technology.

Posner (1989) characterized a text as an artifact, instrument and coded meaning. Unlike a script, in its most abstract definition a text is not necessarily sequential. For the moment, I stick to scripts and their sequentiality. Going though a text is the performance of an ability to absorb it. When a text contains a sentence, this is sequential, and grammar and syntax provide the rules for forming the axis of the script, with its sequence of nodes. A lexicon provides rules for substitution into the nodes. Substitution entails reference. The class of substitutions constitutes the reference of a term. Hence the use of the term 'reference line' in figure 1.

An individual speech act (*parole*), like acts more in general (including acts of production in a firm, or transaction between firms), constitutes a substitution into a node in a script. Intersubjectively shared scripts of communication constitute *langue*. Correct reference ('truth') is judged on whether *parole* is consistent with *langue*; i.e. whether substitutions into shared scripts are 'permissible'. Permissibility is primarily judged on whether the substitution works. This links back to our pragmatic interpretation of meaning and truth. In any script, each node will in general have a range of permissible functional equivalents, which may be interpreted as synonymous terms, but in principle the synonymy is restricted to the node in that script: synonymy depends on context. *Parole* is produced on the basis of sense, which arises from personal experience with scripts. In personal experience, scripts are derived from intersubjectively shared scripts (*langue*), but are adapted in idiosyncratic practice. Practice with the use and adaptation of scripts yields 'sense': the way in which people decide upon substitution into nodes ('reference'), as a basis for *parole*. The process of adaptation and development of scripts is described in the following paragraph. Personal adaptation of scripts is a source of variety and hence of innovation.

The construct of a script is of interest also in economics and business, to model both consumption and production. In consumption it indicates that some

2.3 Development of scripts

Now we will see how scripts emerge, evolve and develop to yield novel scripts, and how this may elucidate the process of the different stages of development proposed before.

A novel, recently invented script is indeterminate and unstable in the sense that the identification and sequencing of nodes, and effective substitutions into them

are unstable: best practice is not yet clear. As application proceeds, in the stage of consolidation, more insight is gained from repeated trials in the context in which the script was first conceived and found to be successful to some extent. By experimentation, the best sequencing and substitutions are established, and this yields what was earlier called a 'dominant design' or 'best practice'. Efficiency increases by the elimination of redundant nodes and inappropriate substitutions, and a narrowing down to optimal and parsimonious procedures.

In the next stage of generalization, the script is applied in novel contexts. This leads to differentiation in the form of:

Parametric differentiation: different substitutions into nodes in different contexts. For example: to adjust for differences in capabilities of labour in different contexts, or in sources of energy, or in available materials, or in technology of maintenance and support, technical standards, etc. A more specific example, using the restaurant case, would be: paying by plastic money (card) rather than cash, in the payment node of the script. Note that the emergence of such a new substitution generates an extension of the reference of plastic money: it can now also be used in restaurants. This type of change appears to be equivalent to the earlier notion of 'parametric change', and therefore we adopt that term for this form of differentiation.

Structural differentiation: different sequencing of nodes, dropping or adding nodes, or even different sets of nodes, in different applications. These are called different 'tracks' of the script. A example in the restaurant script is that there are different tracks for a self-service diner and a service restaurant: in the first one pays before and in the second after eating and seating. Or, more radically, to a drive-in hamburger shop, where entry and seating is replaced by staying in the car. If assimilation fails, i.e. one cannot fit an event into any script, one is facing a puzzle or anomaly. Events that should but do not fit into a given script are 'tagged' onto the script, in a fund of unsolved puzzles.

Reciprocation: a script becomes connected, in at least one of its branches, with at least one branch of another script, first by shared substitutions into nodes and next by shared nodes (i.e. sets of substitutions). For an example in the restaurant case, perhaps (this was not checked for historical accuracy), self service restaurants

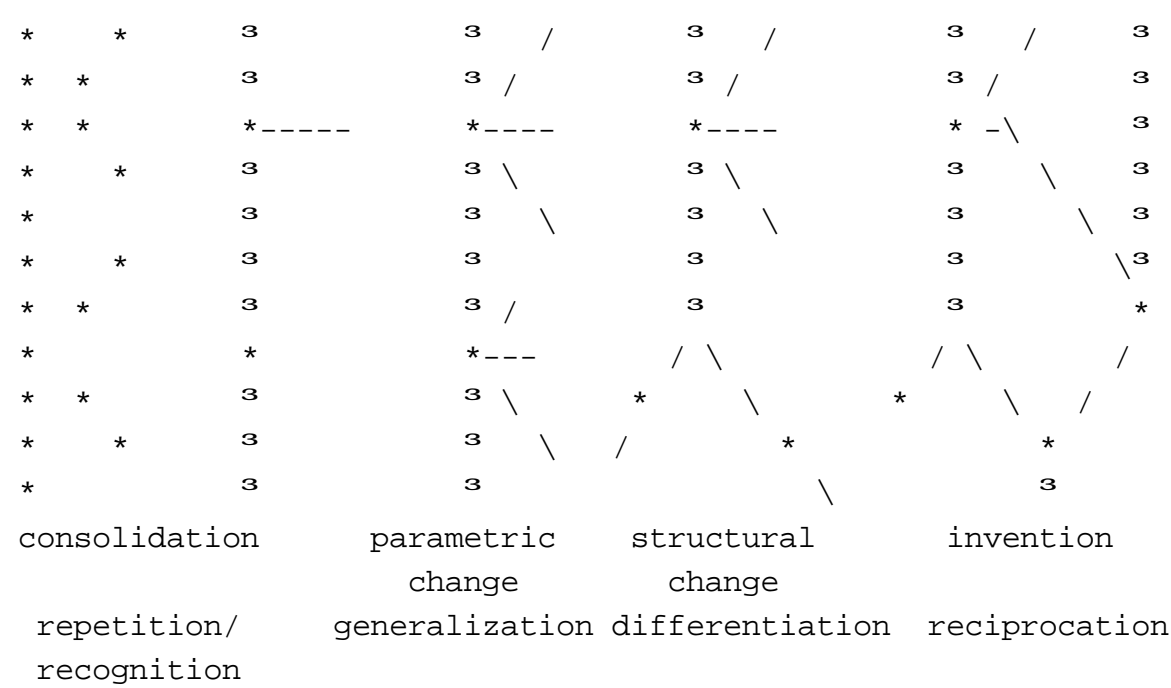
emerged from self service grocery shops when those started to offer ready-made food. Ready made food is then shared between the shopping and the restaurant scripts.

Invention: triggered by reciprocation, nodes or branches from diverse scripts are reconfigured into a new script.

Consolidation: at first the novel script is messed up with mismatches between elements from the original scripts. Nodes or substitutions are included that do not belong, or nodes are put in the wrong order. But there is no existing norm or model to identify this, and increase of effectiveness or efficiency is a matter of learning by doing. After elimination of inappropriate elements, in a 'cleaning up', this yields the standard, paradigm form or 'prototype' of the script.

The process is illustrated in figure 2.

figure 3: development of scripts



Invention can occur on different levels. It may lead to differentiation in the form of a branching of an existing script. In the restaurant case: the reciprocation between a self service shop and restaurant in the sharing of ready-made food may have triggered the idea of a self service restaurant. Note that in this way the 'trans-script reference lines' (figure 1) may form a trigger for reciprocation, leading to invention: the sharing of a term between scripts may stimulate the carry-over of an in some way related term from one script (base) to the other (target), in an act of metaphORIZATION. 'In some way related' here can mean: the term carried from base to target in the base is a substitute or a complement for the term that was already in common, in relation to a given node in the base. Or the element that is carried over can be related as follows: a whole node (or other part of a script) is carried from the base to the target.

Note that I use the term 'invention' rather than 'innovation' advisedly, in accordance to the distinction made by Schumpeter: it constitutes a new way of doing things, but it still needs to prove its viability to be called an innovation. In terms of my analysis: it still has to go through the initial stage of consolidation.

Invention can also yield more fundamental novelty. This notion of different degrees of invention and innovation is also part of the innovation literature. For example: the leap from service to self service shopping required a substitution of movement of products, fetched from shelves by a shop attendant for a waiting customer, by movement of customers making their selections from the shelves. In terms of scripts: in a given script (shopping) terms (products, consumers) were switched between nodes (movement, waiting). This may be triggered by reciprocation from a script in which it was normal practice to have consumers rather than products move. For example: fresh conscripts filing past a line of bits of uniform and other gear to compose their sack.

Note that in our analysis there is an important relation between the stage of reciprocation and the role of metaphor. In fact, one could say that the one constitutes the other, if we employ the definition of metaphor as 'cross-script substitution' that we gave before. The importance of metaphor for innovation was recognized in a

recent article by Nonaka (1995). In the later stage of consolidation, the metaphor develops into what is then seen as literal description.

Part 3: APPLICATIONS AND IMPLICATIONS

Now we proceed to implications and applications. They are many, and here we can only give some preliminary indications. First, we consider to what extent we are now able to solve the puzzles set out in Part 1. Next, we consider implications for the conceptualization of production processes, and in that context the management of people, the notion of the identity of the firm, and boundaries of the firm.

3.1 Puzzles

The main puzzles we identified in part 1 were: the relation between continuity (exploitation) and change (exploration), and the multi-level problem of learning on the levels of people, organizations and networks of organizations.

We identified different stages of development, which to a considerable extent reconcile the demands for both continuity and change. One can continue the exercise of present scripts while adapting them along the steps of consolidation, generalization, differentiation, reciprocation and invention. We need to investigate further how this is to be managed. We turn to that in the next paragraph.

From the start, we took the resource based view of the firm for granted: the firm consists of an idiosyncratic set of competencies based on partly non-contestable resources (financial, human, social). In Part 1 we indicated the neural network metaphor of the firm. With the notion of a script we now proceed from that metaphor to a model. We might characterize a firm as a set of scripts that have evolved: in the form of primary processes, secondary supporting processes, other communicative relations between people. Behind those are the scripts that constitute the cognitive categories of people that affect the organization. But if cognitive

categories are scripts, perhaps we can turn the notion around to say that scripts with nodes that include activities of people communicating with each other also constitute the cognitive categories of the firm, transcending those of the people in it. In other words: the firm has a cognitive identity in the form of scripts with people constituting nodes or contributing actions to nodes. We note also that a node in a script, when scrutinized under a magnifying glass, in turn consists of scripts. This suggests a fractal structure, with possible chaotic and indeterminate traits of cognition¹¹. We need to investigate further how, more precisely, firm level conduct and cognition arise from the level of people; how this relates to communication in the firm, and between firms. This is related to the previous question how to manage people in scripts, and the role and working in this of culture and other institutions.

Concerning carriers of data or knowledge, in Part 1 we recognized hardware, documents and people. Knowledge being contingent upon categories, the data carried can become information and next knowledge only if they can be fitted into the cognitive scripts of those who receive and the carriers. This is a further elaboration of the notion of 'absorptive capacity' (Cohen & Levinthal 1990). Now we add organizational scripts as carriers: organizational procedures, partly embodied in organizational structure. In other words: the memory of an organization is distributed across documents, installations, memory of people and organizational scripts.

Is there anyone who has the categorial scripts to fit the constellation of organizational scripts into; to make sense out of them and understand them? Probably not: who could that be? It may be the task of management to fulfil that function, and they will be able to grasp some subscripts, but they also contribute to nodes and are themselves part of scripts. In that sense, an organization cannot make sense to itself; does not fully know what it is doing. For that, outside consultants may be of some help. That also is why organizational development is largely based on self-organization, in the forms of developing scripts, according to the process set out above. The process can be influenced not by specifying target outcomes, but by

¹¹ The possible connection with fractals was suggested by László Pólós.

affecting the underlying drivers of the process: consolidation, generalization, differentiation, reciprocation.

The non-contestability of at least some of the resources of the firm is consistent with our constructivist epistemology: cognitive competence is based on categories, and competence in general on scripts, that have been developed in learning by doing, in interaction with the physical and social environment. That implies that actors have different competencies to the extent that they developed in different environments, and that one cannot simply buy into another's (cognitive) competencies, if one's own cognitive categories cannot absorb the products of the others'. It also implies the danger that one cannot perceive what lies outside the scope of one's cognitive competence. However, there is a need for a focus of activities. One cannot do everything well, and to have a chance of surviving in technological and commercial races one must concentrate on one's core competencies. This yields the notion of the 'firm as a focusing device' (Nooteboom, 1992a). But focus of perception and competence implies the risk of not perceiving and reacting to relevant threats and opportunities. This problem is related to the earlier problem of continuity versus change. How does a firm reconcile the tension between focus and scope, and between continuity and change? While we have a basis for an analysis of these questions, we still need to build on it.

In particular, an important question is whether there is any single, universal way to manage, regardless of circumstance? And can a firm be managed in a single fashion that applies to all parts of it? (Nooteboom, 1989, 1992b; Weick, 1982). What if one part of the organization is in the stage of consolidation, which requires a narrow focus, and another in the stage of reciprocation, which requires tolerance of more or less chaotic variety? How can one manage the balance between continuity and change in different parts of a firm, and what are the implications for the boundaries of the firm? We will return to these issues later.

For further research, the question also arises how the theory can be further formalized, beyond the mere notion of scripts, to yield an improved account of their dynamics. This will be needed to develop a true 'logic of change'.

3.2 Organizational scripts

Now, following Gioia & Poole (1984), I apply scripts as representations of competencies in organizations, in the form of processes of adding value, which constitute an organization's 'cognitive repertoire'. I propose that the notion of a script is useful for a conceptualization of knowledge and competence, which clarifies a number of important issues in organizational learning. If cognitive categories of people are scripts, perhaps we can turn the notion around to say that scripts with nodes that include activities of people communicating with each other constitute the cognitive categories of the firm, transcending those of the people in it. In other words: the firm has a cognitive identity in the form of scripts with people constituting nodes or contributing actions to nodes (Weick & Roberts 1993). This cognitive identity is close to the culture of a firm (Cook & Yanow 1993). This solves a problem in the literature, which has often backed away from the idea that organizations have knowledge, in some sense, other than some unspecified aggregate of the knowledge of individuals in the organization, and it also goes beyond simple, unreconstructed analogies between learning on the level of individuals and on the aggregate level of the firm (Cook & Yanow 1993).

The notion of an organizational script constitutes a further refinement of the notion of organizational routines from the literature (Cyert & March, 1963; Nelson & Winter 1982). In a primary process (the process of adding value), the axis of a script represents a stream of entities, that undergo transformation in nodes of the script. The entities may be goods, people and information. There may be parallel scripts or bits of scripts, and they may merge or deviate at nodes. For example, in an airline script we have streams of passengers plus luggage, crew, catering, fuel and planes arriving at various airport entrances by cars, trains, trucks or by their own movement. At check-in, passengers and luggage are separated, but along subsequent parallel sub-scripts they undergo a more or less similar procedure for a security check. At embarkation and loading, passengers, luggage, crew, catering and fuel converge upon the plane. And so on. Along the way, data are collected, processed

and dispatched at various nodes. It offers a more developed and precise notion of what organizational cognition may be, beyond individual cognition.

Organizational scripts can in principle be reconstructed and plotted by an analysis of processes of production, administration and communication in firms. They can be coded 'in principle', because as in individuals, in organizations scripts may be tacit (Polanyi 1962, 1966, 1969); not known explicitly to anyone. In organizations, people participate in a node of a script, perhaps without anyone grasping the script as a whole. This connects with the distinction between 'procedural' and 'declarative' knowledge (Cohen & Bacdayan 1994, Cohen 1991).

I propose that in general, when we put a magnifying glass to a node in a script, the node is also seen to consist of one or more scripts. Also, in general a script is embedded in higher level scripts, in the sense that either it forms a node in such a script or produces a substitution into such a node. In other words: scripts contain subscripts and are part of or feed into superscripts. Organizational scripts have a nesting of subscripts, going down into scripts embodied in neural networks of people. They may form part of superscripts in the form of organizational networks, industries, economies and the world economy.

The functioning of people in nodes of organizational scripts is governed by their 'reactivity' to events (Saraph 1994). A well developed (richly structured) form of reactivity is based on a 'repertoire': terms that may serve as substitutions into nodes, a choice procedure for selecting among them, and an implementation of such substitutions.

The choice procedure in a repertoire requires cognitive capacities: perception (awareness, sensitivity to stimulus), interpretation (meaning creation, understanding, knowledge) and evaluation (goal congruence). The scope of a repertoire refers to the set of terms, and this may be narrow or wide. The choice procedure may be flexible, i.e. variable under change of conditions, or strict. Implementation requires skill, commitment and energy. The choice procedure is closely related to the notion of sense: the way in which the choice of substitution into nodes takes place. People may be involved in different nodes of a script, and in different scripts within a firm. They are certainly involved in many scripts outside of

their role in firm, 'qua persona' (Ring & v.d.Ven, 1994), and therefore have a range of repertoires. Reciprocation may yield a carry-over of substitutions or nodes between inside and outside scripts, but this is restricted to the extent that choice procedures are strict. People may be rotated across nodes or scripts.

3.3 Management of scripts

Efficient performance of a script requires appropriate substitutions, which requires appropriate repertoires. A crucial question of management is this: how to guide the development of repertoires so as to achieve an adequate balance between continuity for the sake of good performance, and adaptation of repertoires and the configuration of scripts for the sake of survival under changing conditions. To affect reactivity one needs reactivity to that reactivity. Reactivity to one's own reactivity constitutes self-awareness (Saraph 1994). The step to such self-awareness may seem like second order learning, but in our analysis the change of one's own repertoires may emerge from the process of development set out before, if room and opportunity are allowed for generalization, differentiation, and reciprocation, to achieve innovation.

Should management manage the reactivity of workers by specifying their repertoires? Traditional notions of 'strategic planning' seem to be based on that perspective. How does management obtain the appropriate meta-reactivity (reactivity to workers' reactivity)? For that, it should have self-awareness; reactivity to its reactivity to the reactivity of workers. On what learning would that be based? Or should it subject its meta-reactivity to the people's reactivity to that, and then react to that reactivity? In other words, should it govern by feedback to its governance? Or should management rather govern on the basis of the self-awareness of people; on the basis of people's reactivity to their own reactivity, according to the logic of change?

When we apply our theory of learning as development of scripts, it connects with the distinction in the literature on organizational learning between innovation of components and 'architectural innovation' (Henderson & Clark 1990). The nodes

correspond with the components and the 'architecture' with the way in which the nodes are connected in a logical, causal or temporal order. Architectural innovation constitutes second order learning, in which nodes from different scripts are recombined into a novel script. The anecdote goes that Henry Ford was inspired to his invention of the assembly line by the composition of order packages in a mail-order firm: delivery boxes on a belt moving past attendants sitting in front of shelves of products, and putting something in the box or not according to the order slip attached to the box. It was quite a leap to substitute this script for the old script of one craftsman assembling different parts on a given spot. Movement of a carrier (box, car frame) is substituted for the moving of parts. Again, terms are switched between nodes, this time by reciprocation from a mail-order script.

After invention, we are back at the first stage of consolidation: the removal of ill-fitting remnants from previous scripts, rearrangement of nodes, etc. I give two further illustrations. When building construction shifted from wood to iron and later steel, this was first attempted as a mere functional substitute of a new material in the script of wood construction. Many nodes remained the same. For example, heating and cooling as a method to harden wood seems similar to heating and cooling to harden iron. But unlike wood, metal can be welded. At first, wedge shaped connections required for wood construction were retained while for metal they do not make functional sense, so that this node in the construction script was later dropped. Later, when plastic started to replace metal, it was treated like metal in being shaped on a mould. Pouring or pressing plastic was substituted for pouring or pressing steel into a mould. Subsequently better use of the material properties was made in the cheaper procedure of blowing a stream of plastic into shape¹². Before electric light was implemented in cars, direction indicators were mechanical swivelling devices: a manual script was mechanised. When electrical light came, it was first built into the swivelling device (substituted into an existing node), until someone hit upon the

¹² With the added advantage of getting rid of the "male" part of the mould, thus reducing the "transaction specificity" of the investment.

much cheaper (because non-mechanical) device of a blinking light (replacement of a node). The prior solution in retrospect seems quite ridiculous.

The sequence of stages satisfies conditions of survival. The condition that during the development of novelty there must remain sufficient continuity as a basis for production. As we develop scripts, the show must go on. Furthermore, it is by the process of generalization and differentiation that we develop the motive to innovate: established practice is getting messed up with differentiation, and misfits in different contexts ('tags') accumulate. Furthermore, by the identification of misfits, and comparison with other practices that we run up against, we obtain hints and the elements for 'novel combinations' that seem promising or at least interesting. How else would we obtain the incentives for innovation, and indications where to look for it? It is counterproductive to drop and replace operating procedures too soon, before one knows its limits and possibilities for replacement. It leads to random drift rather than improvement (Lounamaa & March 1987).

Scripts can be retained, in the sense of being present in knowledge in a procedural or declarative sense, in a weak or a strong form. In a weak form, only the set of nodes is retained, but in strong form also the 'architecture', in terms of logical, causal or temporal connections between the nodes, in the script. Note that one can procedurally retain a script in strong form (there is an architecture), without knowing it in a declarative sense. One may also retain a script procedurally only in weak form. In that case one is in a stage of trying to cope with a novel *modus operandi* without a determinate architecture; the beginning of a new script, which has not yet consolidated into a prototype. An organization can have procedural 'knowledge' in a strong sense, without any person in the organization having it, by having a script, embodied in a given *modus operandi*, which involves multiple people who all have strong knowledge of only part of the script (procedurally or declaratively), or only have weak knowledge of the entire script. Such a script can be stable under turnover of people, if new entrants into the script are adequately instructed (procedurally or declaratively). Such procedural organizational knowledge can become declarative, by specification of the script in operating procedures.

Corresponding to the distinction between procedural and declarative knowledge, there are different ways of obtaining (learning) or transferring (teaching) a script. On the level of the individual person, one can learn declaratively, as a student, by studying a schematic representation of the prototype of the script, as a standard operating procedure, encoded in some form. This requires that the teacher offer declarative, encoded knowledge. One can also learn procedurally, as an apprentice, by imitating observed behaviour of one or more 'masters', in a 'community of practice' (Brown & Duguid 1991), and trying it out in practice, subject to correction by that community. In this way, procedural knowledge is a social construction, in a context of application (Lave 1988).

For procedural learning, distance matters more than for declarative learning, because it requires more than reading documents: observing a practice, in its context, and having one's own performance observed for correction, perhaps requiring also touch, hearing, smelling. Furthermore, it requires familiarity and trust to built up in the 'community of practice'. In other words, procedural learning requires multiple media, and ongoing interaction in various contexts. When knowledge is procedural and tacit, it is difficult to license, and one may need a joint venture, with joint production, to establish transfer (Kogut 1988).

Generally, when firms grow large, with the need and opportunity of delegation and specialization in different activities in different departments, procedural knowledge with its direct, face to face visual and oral coordination and communication no longer suffice, and ways of doing things must be made explicit and explainable, i.e. must be turned into declarative knowledge, and must be documented to form instructions and SOP's across departments or subsidiaries. In other words: transformation into declarative knowledge and codification are required for diffusion over large distances and many people.

Procedural knowledge can in principle, and to a certain extent, be elicited to be encoded and systematized in the form of declarative knowledge. This can be very useful. In the 17th century, when Holland was the global leader in shipping, the Dutch built ships on the basis of only rough sketches, with detailed manual instructions by the designer at the shipyard. Apprentices had to accompany the master to the

yard to learn to imitate his craft. There were many quarrels between master and builders about interpretation of instructions, measures etc. The British invented the use of detailed technical drawings and written specifications for construction. This provided a basis for more delegation, more precision and contractual clarity in construction, scientific method and research in design, and enabled formal teaching in classrooms to larger numbers of students. In other words, it reduced transaction costs. Thus, it contributed to a number of factors which caused the British to surpass the Dutch.

But often, in the transmission from procedural to declarative and from tacit to encoded knowledge elements get lost. In declarative teaching, next to the prototype, some of the main differentiated tracks may be included, plus perhaps some of the anomalies tagged onto the script. But complete transmission would yield a regress: one would need to specify all subscripts and superscripts, and at some point these are bound to remain tacit. In any finite explanation one cannot keep on explaining the terms of the explanation. Good teaching requires illustrative practice. Good practice, with all its inveterately tacit elements, rich experience with different tracks of scripts and tagged anomalies, with corresponding 'work-arounds', cannot without any unspecified residual be completely canonized into written procedures, manuals or training programmes (Brown & Duguid 1991). It is one of the pitfalls of management to think that it can be. The inadequacy of it is illustrated when processes break down because people 'work to rule'. It is also illustrated in the insight that for diffusion of knowledge it may be better to rotate staff than written rules or procedures (Cohen & Bacdayan 1994).

The building of repertoires can proceed in different ways:

Specification. This entails the imposition of coded contents of repertoires that are to be adopted. This clearly requires declarative knowledge of the scripts. In innovative activities, after invention and at the beginning of the consolidation stage, this is impossible, because the performance is not yet determinate, and is largely tacit. Next, when it is beyond that stage, things get lost in the transcription. The result constitutes a mere datum for the recipient, and his performance depends on his capacity to absorb it and transform it into information, and from there into perfor-

mance. If, for example, the perception, interpretation or choice in a prescribed repertoire conflicts with similar procedures in the recipient's existing repertoires, it literally does not make 'sense'. Apart from these complications, prescription may work when the need for continuity is paramount.

Imitation. Determine an exemplar of model performance, demonstrate it, and let people imitate it. Perhaps with some documentary support (there may be combinations between this mode of imitation and the previous mode of prescription). Imitation can happen at an earlier stage of development than prescription on the basis of transcription, when knowledge is still procedural rather than declarative, but not too early, because the performance requires a certain amount of stability to be imitated. It entails that the recipient forms his own repertoire by imitation of model performance. Since a given performance can be achieved on the basis of different repertoires, in other words repertoire is under-determined by its performance (in the same way that theory is under-determined by its predictions), this may lead to considerable deviations from the model as circumstances change. The recipient may have imported elements from repertoires in other scripts, probably including scripts from his personal experience. Furthermore, according to my epistemology, cognitive categories, which are part of repertoires, develop in interaction with the physical and social environment, according to stages discussed before. This may be good, since the first (importation from other scripts) provides a source of variety, and the second (development from application) allows for testing and for a connection between adaptation and current performance. It requires appropriate self-awareness of the people involved. Management may want to affect this self-reactivity of people, and the question comes up again on a higher level whether this is to be done by specification of a repertoire (for people to adapt their repertoires), or the setting of models for imitation. The basic idea is that management may want to somehow restrict the direction of change, to maintain sufficient continuity, or to guide the change in the direction of certain overarching goals. Full repertoires for affecting the change of reactivity seems unlikely: one would have to be able to predict what cannot be predicted. More likely would be simpler institutions to restrict or guide the change. Here, one thinks of the role of culture as an institution: certain models of conduct,

embodied in myths, may provide a model for goal selection, and certain rituals may confirm certain practices for the sake of continuity.

Management of meetings. Since according to my theory cognitive categories develop from interaction with the physical and social environment, one can influence change of repertoires yet more indirectly, by governing the environment in which people develop their categories. A main instrument here is the pattern in which people communicate and meet; in other words the design of scripts; in other words organizational structure. In this way also one could affect the balance between continuity and change. But such management by structure would require a certain amount of structural flexibility. And since the effect is very indirect, it would be difficult to predict.

3.3 Identity and boundaries of the firm

What happens when someone drops out from a process? Does it change the identity of the firm? Or would that require a larger scale replacement of entire scripts? If scripts cross boundaries of the firm, where do those boundaries lie?

Replacement of a person, to maintain his role in a node, can be done better to the extent that the role is encoded, so that it can be transferred to a replacement. Or conversely: to the extent that knowledge is tacit, the 'dynamic transaction costs' of transferring it are higher. However, in case of tacit knowledge replacement is not hopeless. People who worked together with the missing person may by imitation be able to supplant him to some extent. Or one may call in a similar specialist from outside.

This is related to the problem of spill-over to competitors through a partner. To the extent that knowledge is more tacit and procedural, and the dynamic transaction costs are consequently higher, the risk is lower than when knowledge is documented or embodied in hardware. Spill-over of tacit knowledge would require transfer of staff: either staff stationed at the partner, or the partner's staff coming over to watch and imitate performance. And this would need to be followed by similar transfer between the partner and one's competitor. But we note that this may

in fact be more difficult to control, because the transfer may be more invisible than the copying of documents.

People may have a stake in maintaining the tacitness of their knowledge, because it enhances their power. Thus it is understandable, for example, that accountants resisted automation, for its ability to encode their tacit expertise, and are losing status and salary now that automation has pushed through.

Rotation of personnel across roles (nodes in scripts) can have several effects and purposes. One is to spread tacit knowledge, in connection with the previous point. A second is to cover against the risk of knowledge dropping out when a person drops out. A third is to facilitate and stimulate innovation in the form of generalization and differentiation. A fourth is to loosen personal ties in which interests of people 'qua persona' go against the interests of the firm.

So, a firm can maintain its scripts in spite of turnover of people. But what if it loses or replaces entire scripts? Will its identity change? It would, if we identified the identity of a firm with its collection of scripts. But to the extent that scripts need to adapt, this would indicate that firms need to continually change their identity. Earlier we indicated that adaptation may not be feasible in the form of renewing the specification of roles, and that it may require imitation of role models or management by meeting, and that this may be guided by guiding the process of development, by imposing restrictions of timing, and limiting or directing the scope of generalization, differentiation and reciprocation, by means of organizational culture. Perhaps we could identify organizational identity with its culture rather than the set of scripts.

We still face the question how with a single culture one can coach the development of different parts of the firm in different stages of development, to combine narrow focus in one part with chaotic diversity in another. Perhaps this yields yet another perspective on the boundaries of the firm, and the tendency to hive off activities in independent units. Traditionally, from TCE, there are the arguments of static efficiency: economy of scale and specialization, and the market incentives of having to secure one's own survival. We added considerations of dynamic efficiency: pressures of globalization, in races in technologies and markets, and

increasing product differentiation, in output and input markets, with the resulting complexity and turbulence, force firms to narrow their focus on core competencies, and to compensate the resulting lack of scope of exploration by means of partners in networks. We also added the epistemological argument that one needs 'outside intelligence' not only for the sake of efficiency, but also as a result of the path-dependency of knowledge, which prevents the ability to perceive, interpret and understand all relevant developments. Together, these two points yield the notion of 'external economy of cognitive scope' (Nooteboom, 1992). Now we add another consideration: the need to hive off activities to prevent incompatibilities in culture, for the guidance of development of scripts in different stages of development.

When scripts extend across boundaries of firms, to utilize the benefits of disintegration, there needs to be coordination, in the form of either interaction or standards at the interfaces (modularity; Langlois & Robertson, 1995), as discussed in Part 1. The latter requires that knowledge is to some extent coded (non-tacit). If it is tacit, coordination has to take place by personal interaction and temporary exchange of staff. This tends to be the case to the extent that the knowledge is newer. Langlois & Robertson pointed out the need for re-integration of activities in innovation, to ensure post-innovation consistency across interfaces. But they also acknowledged that in 'radical innovation', disintegration into 'entrepreneurial networks' is again necessary. We can further enrich the argument with our present theory. When innovation is in the stage of parametric change (generalization), the structure of the script remains the same, and consistency with the script of novel substitutions has to be ensured. But when change is more structural, and certainly when it enters the stage of reciprocation, the structure of scripts themselves is broken up, and to maintain coordination at that stage entails maintenance of scripts, which inhibits innovation in the form of novel combinations of nodes and subscripts from diverse scripts from outside and inside the firm.

There is evidence to support this interpretation. While fundamental scientific discoveries and novel basic technology is a job for large laboratories of government or big industry, their application in the generation of novel product-technology-market combinations is difficult to fit in large bureaucratic organizations. This

explains why such developments have often been achieved outside large firms, in smaller, novel, independent firms, often started by inventors who could not achieve the radical change within the large firm where the invention was made. Examples are: self-service retailing (Nooteboom, 1984a), Computer-Aided Design (Rothwell & Zegveld, 1985), micro-computers (Apple instead of IBM).

In fact, I expect that the present surge of attention to networks of firms arises from the fact that there is a wide potential for applications of novel basic technologies, in a variety of novel combinations. I also propose that the argument contributes to the explanation of Schumpeter's thesis that at the beginning of a long cycle in the economy there is a swarming of innovations in small firms¹³.

¹³ I don not in any wish to suggest that in that stage small firms are universally better than large ones. or that economy of scale no longer obtains. I hold the view that small and large firms have complementary roles to play (Nooteboom, 1994).

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